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# Spent Fuel and Waste Science and Technology

## Update on Salt Disposal R&D LANL WP#SF-18LA01030301

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**Los Alamos National Laboratory**

*SFWST Annual Working Group Meeting*  
*University of Las Vegas*

**May 23, 2018**

# Overview of Activity

**Examine heat/brine/vapor/salt interactions related to heat generating nuclear waste**

■ **Improve numerical modeling capabilities (<https://fehm.lanl.gov>)**

- Validate reactive transport model functions for salt against all available data
- Identify any gaps in capabilities
- Improve existing model functions

■ **Design and execute experiments : generate data to compare to simulations**

■ **Benchmark with other numerical codes  
PFLOTRAN/TOUGH3**



*Iterate*

# Connection to Bigger Picture

## 1. Introduction, Purpose, and Context

## 2. Safety Strategy

### 2.1 Management Strategy

- a. Organizational/mgmt. structure
- b. Safety culture & QA
- c. Planning and Work Control
- d. Knowledge management
- e. Oversight groups

### 2.2 Siting & Design Strategy

- a. National laws
- b. Site selection basis & robustness
- c. Design requirements
- d. Disposal concepts
- e. Intergenerational equity

### 2.3 Assessment Strategy

- a. Regulations and rules
- b. Performance goals/safety criteria
- c. Safety functions/multiple barriers
- d. Uncertainty characterization
- e. RD&D prioritization guidance

## 3. Technical Bases

### 3.1 Site Selection

- a. Consent-based siting methodology
- b. Repository concept selection
- c. FEPs Identification
- d. Technology development
- e. Transportation considerations
- f. Integration with storage facilities

### 3.2 Pre-closure Basis

- a. Repository design & layout
- b. Waste package design
- c. Construction requirements & schedule
- d. Operations & surface facility
- e. Waste acceptance criteria
- f. Impact of pre-closure activities on post-closure

### 3.3 Post-closure Bases (FEPs)

#### 3.3.1 Waste & Engineered Barriers Technical Basis

- a. Inventory characterization
- b. WF/WP technical basis
- c. Buffer/backfill technical basis
- d. Shafts/seals technical basis
- UQ (aleatory, epistemic)

#### 3.3.2 Geosphere/Natural Barriers Technical Basis

- a. Site characterization
- b. Host rock/DRZ technical basis
- c. Aquifer/other geologic units technical basis
- d. UQ (aleatory, epistemic)

#### 3.3.3 Biosphere Technical Basis

- a. Biosphere & surface environment:
  - Surface environment
  - Flora & fauna
  - Human behavior

## 4. Disposal System Safety Evaluation

### 4.1 Pre-closure Safety Analysis

- a. Surface facilities and packaging
- b. Mining and drilling
- c. Underground transfer and handling
- d. Emplacement operations
- e. Design basis events & probabilities
- f. Pre-closure model/software validation
- g. Criticality analyses
- h. Dose/consequence analyses

### 4.2 Post-closure Safety Assessment

- a. FEPs analysis/screening
- b. Scenario construction/screening
- c. PA model/software validation
- d. Barrier/safety function analyses and subsystem analyses
- e. PA Model Analyses/Results
- f. Uncertainty characterization and analysis
- g. Sensitivity analyses

### 4.3 Confidence Enhancement

- a. R&D prioritization
- b. Natural/anthropogenic analogues
- c. URL & large-scale demonstrations
- d. Monitoring and performance confirmation
- e. International collaboration & peer review
- f. Verification, validation, transparency
- g. Qualitative and robustness arguments

## 5. Synthesis & Conclusions

- a. Key findings and statement(s) of confidence
- b. Discussion/disposition of remaining uncertainties
- c. Path forward

# Spent Fuel and Waste Science and Technology

# Connection to Bigger Picture

*2. Physical-chemical properties of crushed salt backfill at emplacement	<b>High Priority FEPS</b>
3. Changes in physical-chemical properties of crushed salt backfill after waste emplacement	
5. Mechanical response of backfill	
6. Impact of mechanical loading on performance of the waste package	
7. Brine and vapor movement in the backfill and emplacement drift, including evaporation and condensation	
9. Mechanical and chemical degradation of the waste forms	
11. Changes in chemical characteristics of brine in the waste package	
12. Radionuclide solubility in the waste package and EBS	
14. Stratigraphy and physical-chemical properties of host rock	
15. Changes in physical-chemical properties of host rock due to excavation, thermal, hydrological, and chemical effects	
16. Mechanical response of host rock due to excavation (e.g., roof collapse, creep, drift deformation)	
17. The formation and evolution of the DRZ	
18. Brine and vapor movement through the host rock and DRZ, including evaporation and condensation	
23. Thermal response of EBS and geosphere (heat transfer from waste and waste packages into the EBS and geosphere)	
*25. Gas generation and potential physical impacts to backfill, DRZ, and host rock	
27. Colloid formation and transport in the waste package, EBS, and host rock (including DRZ)	
28. Performance of seal system	
31. Appropriate constitutive models (e.g., darcy flow, effective stress)	
32. Appropriate representation of coupled processes in process models	
33. Appropriate representation of coupled processes in total system performance assessment (TSPA) models	
34. Appropriate inclusion and scaling/representation of spatially and temporally varying processes and features in process and TSPA models	
37. (Modeling) verification and validation	
38. (Modeling) data and results management	
39. Development of accurate instrumentation and methods for in-situ testing and characterization	
40. In situ demonstration and verification of repository design, with respect to impact on the host rock and the ability to comply with pre-closure and post-closure safety requirements	
41. Demonstrate under representative conditions the integrated design functions of the waste package, backfill, host rock, and ventilation	
42. Provide a full-scale benchmark for understanding coupled THMC processes and comparing measured system responses with model predictions and assumptions	
43. (Confidence-building) Develop generic safety case	
44. (Confidence-building) Comparisons to natural and anthropogenic analogs	
*45. (Confidence-building) International collaboration	
46. (Confidence-building) In-situ testing and demonstrations	
47. (Confidence-building) Verification, validation, transparency, and traceability	

*Stauffer et al. 2015, UFD-2015-000077, modified from Sevougian et al. 2013*

## **High Priority FEPs from scoping workshop for Salt**

**Evolution of backfill**

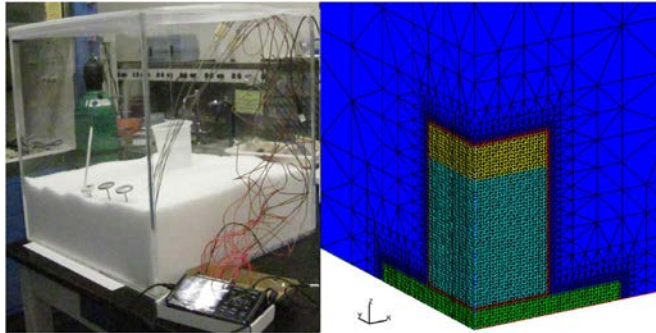
**Strong feedback of water on consolidation**

**Dehydration of ubiquitous impurities**

**Generation of acid vapors (HCl)**



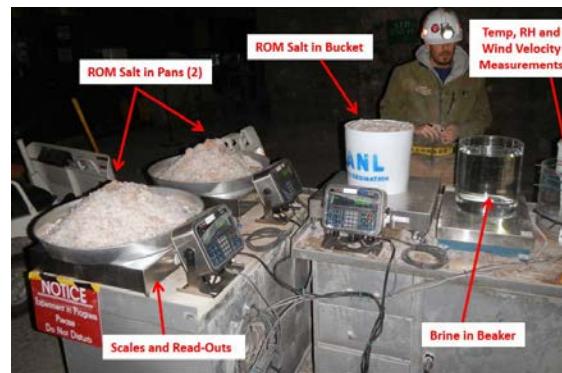
*Salt box*



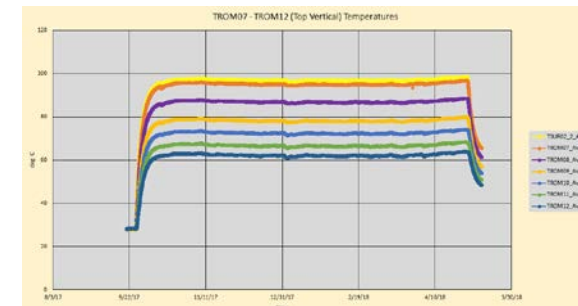
*Fluid inclusions*



*Acid gas generation*



*WIPP canister thermal data*





# Experimental success II

## Field Test – WIPP Heated Borehole

*In progress*



*Gas/vapor sampling tested*



*Feb 2018 Packer holes  
pressure in the hole*

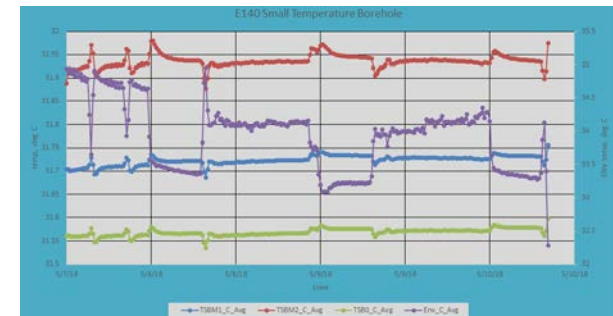
May 23, 2018

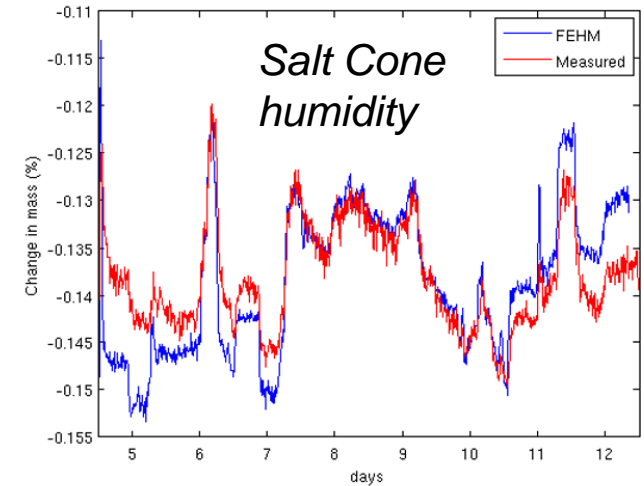
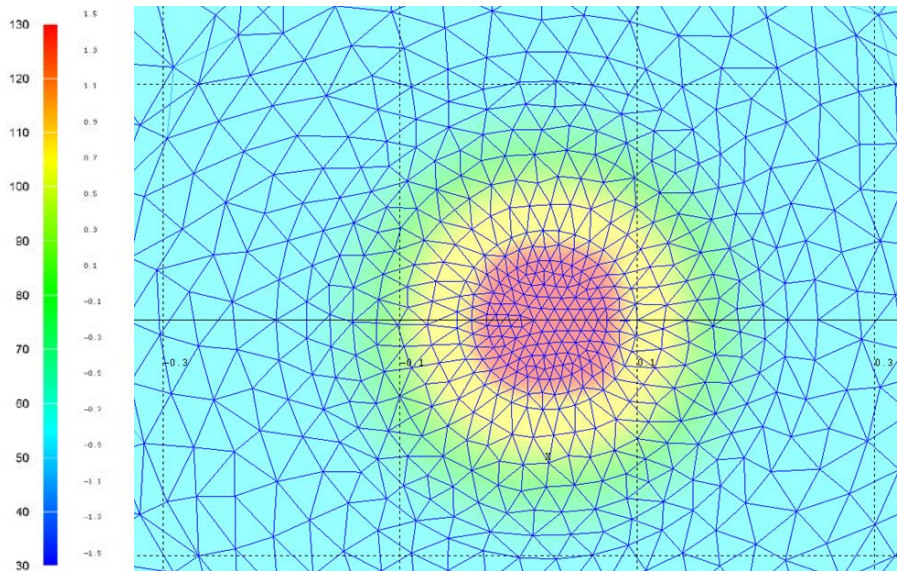
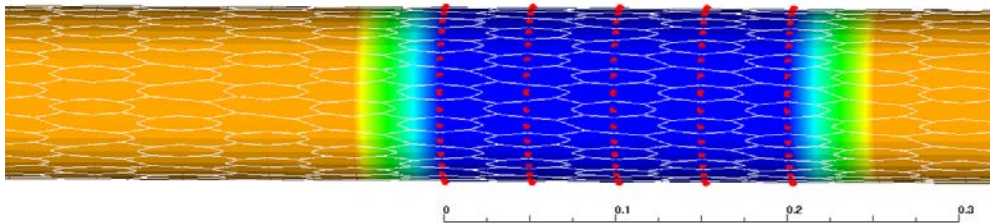


*Nitrogen hooked up safely*

Update on Salt Disposal R&D LANL

*May 2018 thermal data*





*Mass change (%) of salt cone, showing comparison of FEHM model results (blue) to lab measurements (red).*

*Predicted temperature profiles for WIPP borehole test*

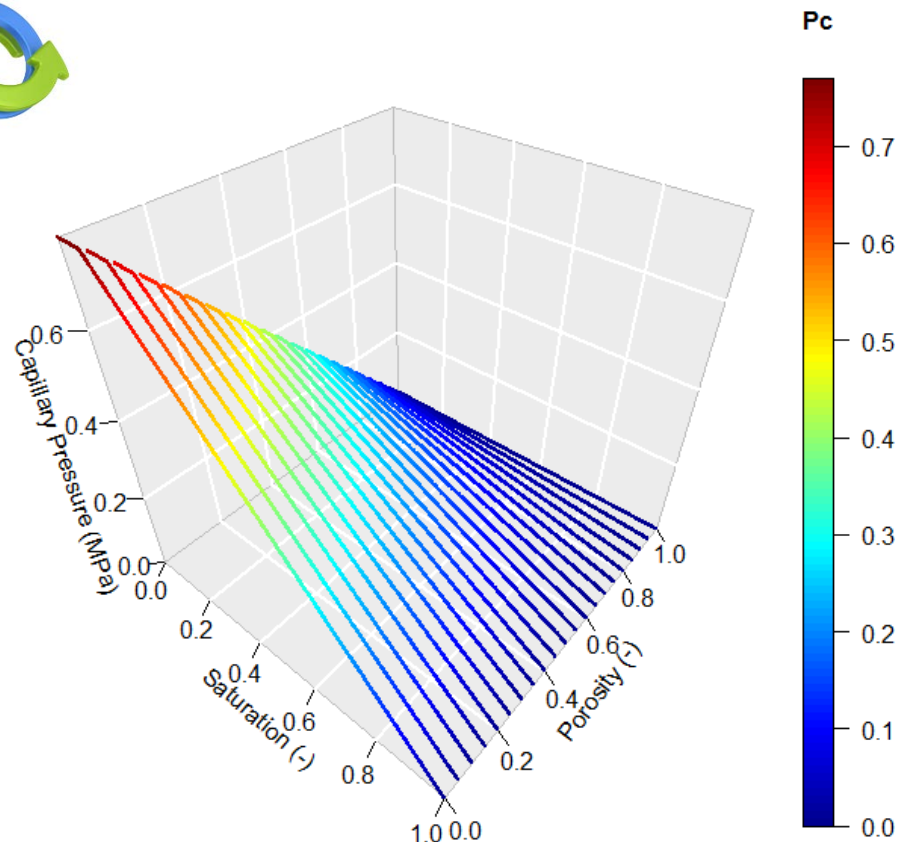
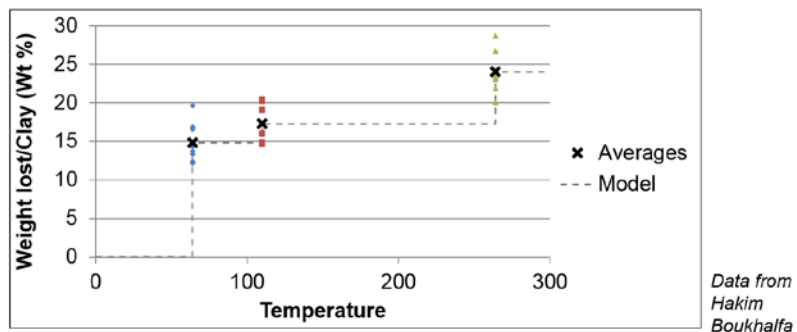


Changes in **porosity** lead to changes in:  
permeability  
thermal conductivity and heat capacity  
vapor diffusion coefficient

Changes in **temperature** lead to changes in:  
thermal conductivity  
salt solubility  
water vapor pressure  
brine viscosity



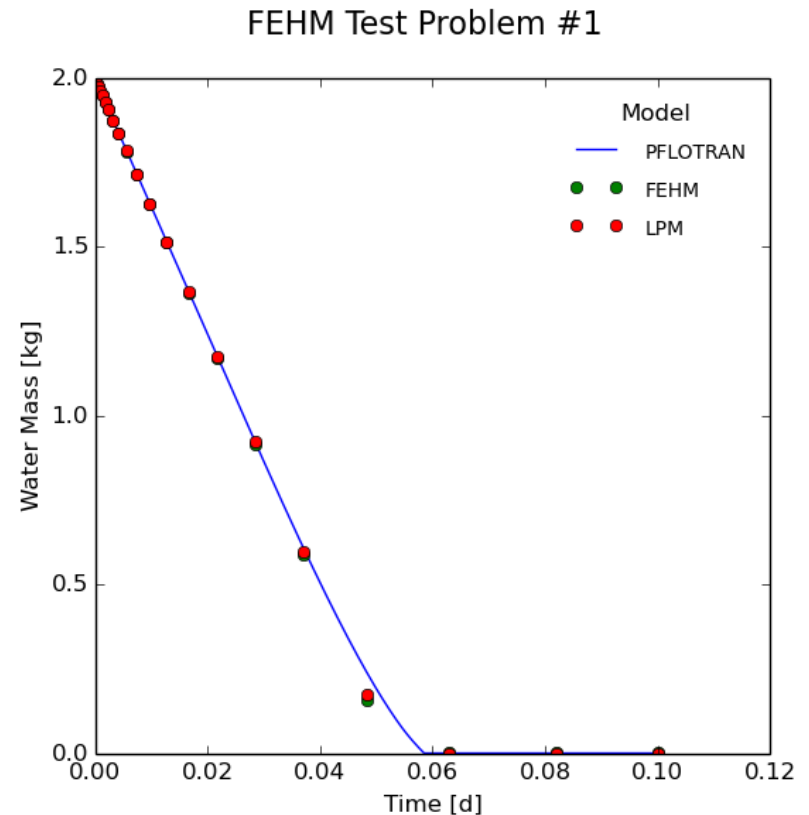
Clay dehydration algorithm based on laboratory data



3-D capillary function

- *LANL and SNL working to add capability to PFLOTRAN based on FEHM experience with code validation tests*

- *Given a constant flow rate we compared the FEHM solution to an analytical solution for water removal using the holding capacity of 20°C air and the air-flow rate*
- *FEHM and PFLOTRAN successfully dry out the matrix water and remove the water in vapor form*



# Spent Fuel and Waste Science and Technology **Future R&D & Integration Timeframe**

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- **Lab and Field results have yielded valuable data – these will guide further R&D efforts for high priority FEPs**
- **Confirming processes and parameters and working to feed results back to PA tools. – ongoing.**
  - Work with SNL to embed new physics into PFLOTRAN continues.
  - Having a dedicated PostDoc or early career staff member on this would help greatly speed up this task.
- **Ensure constancy between DOE simulation tools for the same test cases**
  - This could be tasked in the next year or two.
  - Base test cases on thought experiments and/or proven laboratory data.